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Growth Inhibition and Stimulation by Groundnut Plant Residue

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ABSTRAK

Beberapa kedudukan yang berbeza sisa pokok kacang tanah telah dikaji kesan fitotoksiknya ke atas tumbesaran dan perkembangan pokok kacang tanah dan jagung. Keputusan menunjukkan sisa mengeluarkan bahan yang merencatkan tumbesaran dan perkembangan pokok kacang tanah semasa penghuraiannya. Sisa yang digaul dengan tanah atau yang terletak dibawah biji benih paling merencatkan tumbesaran kacang tanah. Sebaliknya, sisa di atas permukaan tanah atau di dalam tanah merangsangkan tumbesaran awal jagung.

ABSTRACT

Groundnut plant residue at different placements in the soil was tested for phytotoxic and other effects on the growth and development of groundnut and maize plants. Results indicated that the residue released substances during decomposition that inhibited growth and development of groundnut. Residues mixed with the soil or banded in a layer below the seed was the most inhibitory to the growth of groundnut. However, early maize growth was stimulated by the presence of residue on the soil surface or in the soil.

Keywords: allelochemicals, groundnut plant residue, phytotoxic

INTRODUCTION

Groundnut (*Arachis hypogaea*) yields from second and subsequent croppings were reported to decrease by more than 50% of the first crop (Chan, 1968; Cheah, C.H. - personal communication). In most cases the yield reduction was attributed to poor pest and disease management or depletion of soil nutrients. This decrease in yield, however, may also be partly explained by the type of residue remaining from the previous crop. Substantial evidence from the literature shows the presence of phytotoxic substances, called allelochemicals, that are produced by most crops (Guenzi *et al.* 1967; Cochran *et al.* 1977; Robinson and Burdick, 1978; Elliot and Roy, 1982; Yakle and Cruse, 1983, 1984). These allelochemicals may be responsible for the reduced growth and yield observed. However, genotypes of various crop species may differ in their ability to produce or tolerate allelochemicals. Kimber (1967) reported difference in the level of inhibition of wheat *(Triticum aestivum)* growth caused by residues of several wheat genotypes. Maize (*Zea mays*) hybrids also showed some differences in their responses to maize residue (Zakaria and Kaspar, 1990). Growing the same maize hybrids continuously yielded lower than continuous maize when hybrids were rotated (Hicks and Peterson, 1981). The lower yields may have resulted because the hybrids either differed in their tolerance to allelochemicals or in their residue toxicity.

Likewise, groundnut plant residue and groundnut hulls were also reported to inhibit the germination and shoot growth of groundnut, okra *(Hibiscus esculentus)* and cucumber *(Cucumis sativa)* as well as caused decrease in yield and grade of tobacco (*Nicotiana tabacum)* leaves (Robinson and Burdick, 1978; Elliot and Roy, 1982; Zakaria and Razak, 1990). The extract from fresh groundnut plants was more toxic than extracts from partially decomposed or heat-traeted residues (Zakaria and Razak, 1990). However, the inhibitory effect of the residues decreased as time of residue decomposition increased.

The objective of this study was to examine the inhibitory and stimulatory effects of groundnut plant residue at different placements in the soil on the growth and development of groundnut and maize plants.

MATERIALS AND METHODS

Groundnut plant residue of Matjan was collected after harvest, air-dried and then cut to pieces ranging from 1 to 2 cm in length. The potting medium was a 3:2:1 mixture of soil, sand and organic matter. Five treatments were compared: residue on the soil surface, residue banded 2.5 cm below soil surface, residue banded 5.0 cm below soil surface, residue mixed with the soil, and no residue as the control. Eighty grams of residue (equivalent to approximately 10000 kg residue ha^{-1}) were either banded or mixed with approximately 0.0212 m^3 of soil mixture in a 36-cm diameter clay pot. Seeds of either groundnut (Matjan) or maize (Thai Supersweet) were planted in each pot at a depth of 3 to 4 cm. Each pot was given an equal volume of water every two days. Each pot also received 0.7g urea, 1.3g Triple Superphosphate (TSP) and 1.0g Muriate of Potash (MOP) for groundnut and 4.3g urea, 2.2g TSP and 1.6g MOP for maize at planting. Two sets of experiments were conducted using a randomized complete block design with four replications. One set of experiment was harvested at maturity. Plants in each pot were thinned to four seedings and one seedling after emergence for set one and two, respectively. Parameters measured for set one were: extended leaf height of each plant, shoot and root dry weight of the four plants, and shoot to root dry weight ratio. For set two, the following were determined: a) for groundnut - days to flowering, pegging and podding and pot and kernel dry weight per plant at maturity; b) for maize - days to tasseling, silking and maturity and ear and kernel dry weight at maturity. Plants in set one were harvested by washing off soil mixture form the roots. The roots were further cleaned by hand. The cleaned roots were separated from the shoots and dried in an oven at 60°C for 48 h. The shoot and root dry weights and ratios were determined thereafter. In set two, the plants were harvested at physiological maturity. For groundnut, maturity was determined by the method of Boote (1982).

RESULTS AND DISCUSSION

Toxicity of residue on growth of groundnut

Groundnut plant residue used as green manure, compost or mulch may inhibit early crop growth. Bioassay of fresh and partially decomposed residue extracts were shown to inhibit germination and radicle elongation of several crop species (Zakaria and Razak, 1990). Table 1 shows the mean height of groundnut plants treated with residue at different placements in the soil. At 6 DAP, all residue-treated plants were shorter than the control. However, from 10 DAP onwards plants grown in the residue mixed with the soil were the shortest compared to plants in the other treatments. Residues mixed with the soil probably decomposed much faster than surface residues and because allelochemicals sometimes result from decomposition, a greater concentration of allelochemicals may have been produced when residues were mixed with the soil (Yakle and Cruse, 1983; Zakaria and Kaspar, 1990). Additionally, incorporating residues with the soil results in direct contact between residues and roots growing in the soil and thus, may

TABLE 1
Effect of groundnut residue on mean height (cm) of groundnut plants.

Residue placement	Day after planting 6	10	14	18	22
Soil surface	0.4b	5.9a	10.1b	12.9b	16.2b
2.5 cm below soil	0.6b	6.3a	10.2a	13.4b	16.0b
5.0 cm below soil	0.7b	6.1a	10.2a	13.4b	16.3b
Mixed with soil	0.8b	4.9b	9.1b	12.2c	15.6c
No residue	2.1a	6.5a	10.4a	14.1a	17.8a

All means in a column not followed by the same letter were significantly different from one another at 5% probability as determined by Duncan Multiple Range Test (DMRT).

result in a greater effect. The residue on the soil surface or banded in the soil also resulted in plants that were shorter than the control (Table 1). The results indicated that the effect of the surface or banded residue was not only caused by just physical restriction but possibly also by chemical interaction. The groundnut plants might be sensitive to substances released by the residue during decomposition, thus, causing autointoxication. This effect was observed with rice, maize and wheat treated with their respective residues (Guenzi *et al.* 1967: Chou and Lin. 1976).

Plants grown with the residue were lighter in shoot, root and total dry weight compared to the control (Table 2). The shoot and the root dry weight were reduced by between 25-41% and 45-60%, respectively. In addition, the total dry weight was reduced by 32-46%. Zakaria and Razak (1990) reported that the groundnut plant residue extract caused browning and distorted elongation of the radicle of several crop species. This indicated that root growth was the most sensitive to substances produced by the residue, irrespective of its placement in the soil. However, the residue mixed with the soil or banded below the seeds had a higher chance of inhibiting early root growth. The reduction in root growth was also manifested by the larger shoot to root dry weight ratio when the residue was placed on the soil surface, below the seeds or mixed with the soil (Table 2).

Table 3 shows the effect of residue placements on days to flowering, pegging and podding, and pod and kernel dry weight of groundnut at harvest. Early reproductive development of the plants in terms of days to flowering, pegging and podding was not delayed by the residue. The results implied that although early vegetative growth was inhibited by the residue, groundnut plants were able to overcome the effect at the later growth stages. Thus, increasing the time of residue decomposition or weathering of the residue eventually decrease residue toxicity under most conditions (Yakle and Cruse, 1984; Zakaria and Kaspar, 1990). In addition, the pod and the kernel dry weight of plants grown in soil with the residue were lighter than those of the control by 34-56% and 42-66%, respectively (Table 3). The residue not only inhibited early vegetative growth but also the pod and kernel development during the reproductive stage. The placement of the residue relative to the seed also affected the pod and the kernel development. The residue placed below the seed or mixed with the soil resulted in plants having the lightest pod and kernel dry weight. The developing pod might have been in direct contact with the residue, and substances produced during residue decomposition might have influenced both the pod and the kernel development. These findings might account for the reduction in groundnut yield as a result of continuous croppings and which were not totally attributed to insect pests and diseases (Chan, 1968). Another possibility is that the residue might have immobilized nutrients to the developing parts, especially nitrogen and phosphorus (Parker, 1962; Bhowmik and Doll, 1984).

Stimulation of maize growth by the residue

Groundnut plant residue might be stimulatory to early maize growth even though maize germination was inhibited by fresh extract from groundnut plant residue (Zakaria and Razak, 1990). They also noted a stimulatory effect on

Table 2
Effect of groundnut residue on mean dry weight (g) and ratio of groundnut vegetative parts at 22 DAP

Residue placement	Shoot Weight	Root Weight	Total Weight	Shoot:root Ratio
Soil surface	1.83b	0.36b	2.19b	5.08a
2.5 cm below soil	1.66b	0.42b	2.08b	3.95b
5.0 cm below soil	1.45b	0.31b	1.76b	4.68a
Mixed with soil	1.44b	0.31b	1.75b	4.65a
No residue	2.45a	0.77a	3.22a	3.18b

All means in a column not followed by the same letter were significantly different from one another at 5% probability as determined by DMRT.

TABLE 3
Effect of groundnut residue on physiological stages (days) and pod and kernel dry weight (g) at maturity

Residue placement	Flowering	Pegging	Podding	Pod wt.	Kernel wt.
Soil surface	28a	31a	42a	33.26b	23.08b
2.5 cm below soil	31a	33a	46a	35.33b	23.28b
5.0 cm below soil	31a	32a	43a	23.68c	13.88c
Mixed with soil	31a	33a	40a	23.36c	19.51c
No residue	29a	31a	45a	53.64a	40.35a

All means in a column not followed by the same letter were significantly different from one another at 5% probability as determined by DMRT.

germination and radicle elongation from partially decomposed residue. In this study, no differences in mean extended leaf height were observed from emergence until 14 DAP (Table 4). At later growth stages, however, the plants treated with the residue were taller than the untreated plants. The results implied that the groundnut plant residue after a certain period of decomposition was stimulatory to the growth of maize. Ries *et al.* (1977) reported that alfalfa (*Medicago sativa*) produced a substance called triacontanol during decomposition which stimulated the growth and development of maize plants. Other researchers have also reported that the use of soybean (*Glycine max*) residue in a cropping system improved the growth and yield of maize (Welch, 1977; Voss and Shrader, 1979; Hicks and Peterson, 1981). Interestingly, since groundnut is also a legume it can be speculated that the residue released a triacontanol-related substance during decomposition which stimulated the growth of maize.

Table 5 shows the mean dry weight and the ratio of maize vegetative parts treated with the residue. All the residue-treated plants were heavier in shoot, root and total dry weight compared to the untreated plants. The shoot and the root dry weight increased by 64-122% and 42-63%, respectively, while the total dry weight increased by 56-100%. No differences among the treatments and the control for shoot to root ratio indicate that the favourable effect of the residue on root growth will also cause a favourable response on shoot growth. The results imply that root growth is important in enhancing the growth of above-ground plant parts.

The stimulatory effect of the residue on growth of maize, however, decreased with increasing age of the plants and increasing period of residue decomposition. Thus, no differences were observed for days to tasseling, silking and maturity, ear length, ear diameter and ear and kernel dry weights (Table 6). The position of the ear on the maize plant compared to the

TABLE 4
Effect of groundnut residue on mean extended leaf height (cm) at different days after planting

Residue placement	Days after planting: 6	10	14	18	22
Soil surface	3.3a	10.6a	24.6a	44.5a	63.6a
2.5 cm below soil	3.5a	10.2a	23.5a	45.8a	67.2a
5.0 cm below soil	3.8a	10.4a	25.4a	42.3a	68.5a
Mixed with soil	3.1a	10.1a	22.1a	41.5a	65.2a
No residue	2.4a	8.4a	19.5a	36.5b	52.2b

All means in a column not followed by the same letter were significantly different from one another at 5% probability as determined by DMRT.

TABLE 5
Effect of groundnut residue on mean dry weight (g) and ratio of maize vegetative parts

Residue placement	Shoot Weight	Root Weight	Total Weight	Shoot:root Ratio
Soil surface	5.63a	2.38a	8.01a	2.37a
2.5 cm below soil	6.56a	2.28a	8.84a	2.88a
5.0 cm below soil	6.11a	2.16a	8.27a	2.83a
Mixed with soil	4.83a	2.07a	6.90a	2.33a
No residue	2.95b	1.46b	4.41b	2.02a

All means in a column not followed by the same letter were significantly different from one another at 5% probability as determined by DMRT.

groundnut pod which was in direct contact with the residue might be a factor contributing to the differences observed between them. Besides, crop species also responded differently to the residue.

CONCLUSION

The groundnut plant residue left on the soil surface or mixed with the soil can affect seedling growth. The effect might be either inhibitory or stimulatory depending on the crop species. Groundnut plants treated with the residue were shorter and lighter in shoot, root and total dry weight. The residue mixed with the soil was the most inhibitory. The pod and the kernel dry weight were also lighter than those of the untreated plants. However, the residue appears to stimulate the early growth of maize seedlings. The residue-treated plants were taller and heavier in shoot, root and total dry weight. The effect declines with increasing period of residue decomposition, and consequently at maturity no differences were observed. The results indicate that the groundnut plant residue, irrespective of its placement in the soil can inhibit the growth and development of groundnut plants. Conversely, its effect on maize growth is stimulatory to a certain extent.

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TABLE 6
Effect of groundnut residue on physiological stages (days), ear and kernel dry weight (g), and length and ear diameter (cm) at maturity

Residue placement	Vt*	RO*	PM*	Ear wt	Kernel wt.	Ear length	Ear diam.
Soil surface	49a	54a	89a	66.72a	47.39a	16.1a	3.4a
2.5 cm below soil	49a	55a	90a	70.33a	46.88a	15.2a	3.2a
5.0 cm below soil	50a	55a	93a	67.32a	43.06a	14.7a	3.7a
Mixed with soil	49a	55a	89a	81.82a	58.94a	18.0a	3.4a
No residue	50a	55a	93a	71.33a	44.79a	14.8a	4.1a

*Vt - tasseling; RO - silking; PM - physiological maturity
All means in a column not followed by the same letter were significantly different from one another at 5% probability as determined by DMRT.

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